ANKOM

2004 -05- 13

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
20 February 2003 (20.02.2003)

PCT

(10) International Publication Number
WO 03/015315 A1

(51) International Patent Classification[7]: H04B 7/26

(21) International Application Number: PCT/KR02/01533

(22) International Filing Date: 9 August 2002 (09.08.2002)

(25) Filing Language: Korean

(26) Publication Language: English

(30) Priority Data:
2001/47937 9 August 2001 (09.08.2001) KR

(71) Applicant *(for all designated States except US)*: **INITIUM CO., LTD.** [KR/KR]; 8TH FLOOR, GONGDUCK BLDG., 272-6, SEOHYUN-DONG, BUNDANG-KU, SUNGNAM-SI, 463-824 KYUNGGI-DO (KR).

(72) Inventor; and
(75) Inventor/Applicant *(for US only)*: **JANG, Hyun-Sang** [KR/KR]; 207-101, CHUNGKU APT., YANGJI-MAEUL, SUNAE-DONG, BUNDANG-KU, SUNGNAM-SI, 463-921 KYUNGGI-DO (KR).

(74) Agents: **LEE, Kwang-Yeon**; 5th Floor, New-Seoul Building 828-8 Yoksam-dong, Kangnam-ku, 135-935 Seoul et al. (KR).

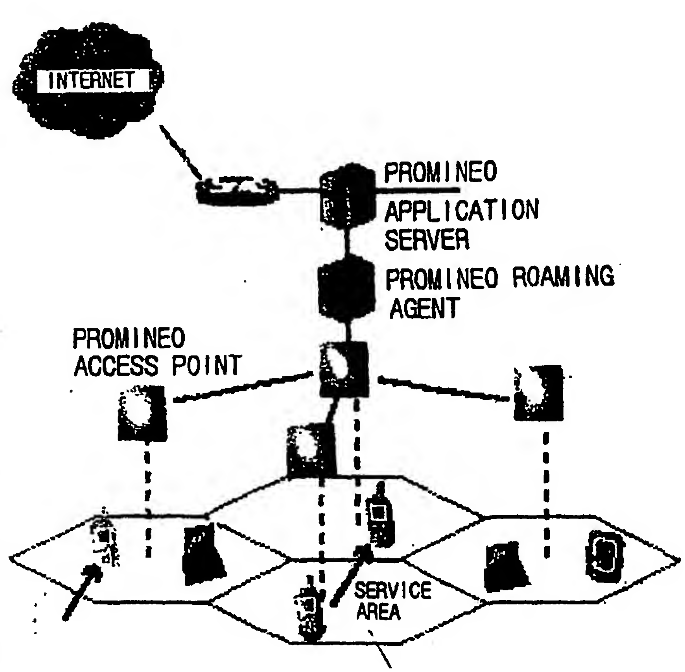
(81) Designated States *(national)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, OM, PH, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

(84) Designated States *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: HANDOVER/ROAMING MECHANISM SUPPORTING SYSTEM IN A SHORT-RANGE WIRELESS NETWORK BASED ON THE BLUETOOCH



(57) Abstract: The present invention relates to a handover/roaming mechanism supporting system in a short-range wireless network based on the Bluetooth including a Promineo-access point (Promineo-AP) which is a network access point (NAP) for connecting a Bluetooth user apparatus through the LAN, at least one Promineo-data terminal (Promenio-DT) loaded with Bluetooth client application software for supporting handover/roaming mechanism, and a Promineo-roaming agent (Promineo-RA) for supporting the handover/roaming mechanism on a wired backbone and managing all the Bluetooth apparatuses within the service area.

WO 03/015315 A1

HANDOVER/ROAMING MECHANISM SUPPORTING SYSTEM IN A SHORT-RANGE WIRELESS NETWORK BASED ON THE BLUETOOTH

TECHNICAL FIELD

The present invention relates to a short-range wireless communication network based on the Bluetooth, and in particularly to a handover/roaming mechanism supporting system which can extend a service area in a short-range wireless communication network using the Bluetooth.

BACKGROUND ART

The Bluetooth which is one of the short-range wireless data communication standards such as the IrDA (Infrared Data Association), wireless LAN (IEEE 802.11) and SWAP (Shared Wireless Access Protocol) is a communication standard for a variety of electronic apparatuses. The five corporations, Ericsson, Nokia, IBM, Toshiba and Intel have composed a consortium called Bluetooth SIG (Special Interest Group) in May, 1998, and defined the Bluetooth Spec. 1.0 in the first forum held in England in June, 1999. The Bluetooth Spec. 1.0 prescribes a data rate of 1Mbps and a transmission distance of 10 to 100m. Member companies have increased to

1900 for about one year, arousing interest of the field. Since the Bluetooth transmits and receives electric waves according to spread spectrum frequency hopping which sets up 79 channels having a bandwidth of 1MHz in 2.4GHz band and changing the channels 1600 times per second, it can be wirelessly connected to a notebook computer, cellular phone, PDA, digital camera, printer, MP3 player and home network apparatus, stably transmit and receive data, and reduce the price and power consumption. It is thus expected that demands for the Bluetooth will be remarkably increased. Compared with the wireless LAN of IEEE 802.11b which is another short-range wireless technology using 2.4GHz band, the Bluetooth which has the transmission distance within 10 ~ 100 meters needs to extend a service area through the handover/roaming mechanism as in the wide area wireless communication network in order to guarantee user mobility. However, the Bluetooth which is designated for removing cables or considers PAN (Personal Area Network) does not handle the handover/roaming mechanism in current Spec. v1.1.

DISCLOSURE OF THE INVENTION

Accordingly, it is an object of the present invention to allow the Bluetooth standardized by the Bluetooth SIG and IEEE 802.15, solve

problems due to frequent inquiries/connections during the movement of a generalized Bluetooth user apparatus, and overcome using distance limits which are one of disadvantages of the Bluetooth by extending a service area through a handover/roaming mechanism supporting system.

To achieve the above-described object of the invention, a handover/roaming mechanism supporting system in a short-range wireless network based on the Bluetooth includes at least one Promineo-access point (Promineo-AP) which is a network access point (NAP) for connecting a Bluetooth user apparatus through the LAN, at least one Promineo-data terminal (Promineo-DT) loaded with Bluetooth client application software for supporting handover/roaming mechanism, and a Promineo-roaming agent (Promineo-RA) for supporting the handover/roaming mechanism on a wired backbone and managing all the Bluetooth apparatuses within the service area. The Promineo-AP connects the Promineo-DT through the LAN, informs the Promineo-RA of BD_ADDR and clock_offset information of the DT, sets up connection according to a command from the Promineo-RA and performs a proxy operation for relaying a PPP diagram, and the Promineo-RA serves as a PPP server for processing PPP connection to the DT in a sub-network including the NAPs, recovers the PPP connection through tunnel end point redirection after the handover

mechanism is completed, and thus maintains the previous PPP connection state during the handover/roaming mechanism regardless of disconnection of the Bluetooth link.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a basic structure view illustrating a handover/roaming mechanism supporting system in a short-range wireless network based on the Bluetooth in accordance with a preferred embodiment of the present invention;

Fig. 2 shows PPP termination in the RA;

Fig. 3 shows an initial connection setup in accordance with the preferred embodiment of the present invention;

Fig. 4 shows measurement of a clock offset in accordance with the preferred embodiment of the present invention;

Fig. 5 shows link loss detection and handover mechanism based on a radio signal strength indicator (RSSI);

Fig. 6 shows link loss detection and handover mechanism based on a link supervision timer; and

Fig. 7 shows one example of network constitution.

BEST MODE FOR CARRYING OUT THE INVENTION

Example 1

Fig. 1 is a basic structure view illustrating a handover/roaming mechanism supporting system in a short-range wireless network based on the Bluetooth in accordance with a preferred embodiment of the present invention. Referring to Fig. 1, the handover/roaming mechanism supporting system includes a Promineo-AP which is a NAP for connecting a Bluetooth user apparatus through the LAN, a Promineo-DT which is a data terminal loaded with Bluetooth client application software for supporting handover/roaming mechanism, and a Promineo-RA which is a roaming agent for supporting the handover/roaming mechanism on a wired backbone and managing all the Bluetooth apparatuses within the service area.

The Promineo-AP can include up to four Bluetooth modules. The each Bluetooth module can be used to connect the DTs through the LAN or can be used for pre-paging to detect the position of the DT adjacent to the AP. In addition, the Promineo-AP is positioned between the DT and the RA for informing the RA of BD_ADDR and clock-offset information of the DT and performing relay operations such as connection setup according to a command from the RA. A PPP server exists in the RA, not the AP, when the

RA is used for handover/roaming support. In this case, the AP merely performs a proxy operation for relaying a PPP diagram between the DT and the RA.

The Promineo-RA serves as a PPP server for processing PPP connection to the DT in a sub-network including the NAPs. The Promineo-RA performs a tunneling operation with the NAPs for receiving data through an internet and transmitting them to an appropriate NAP, buffers IP packets when the DT moves to a different NAP, and redirects them to the NAP. In addition, the Promineo-RA stores and manages information (status, position, BD_ADDR and clock-offset) of the DT existing in the sub-network, manages the handover mechanism and provides an appropriate command to the NAP. For example, when the DT connected to one NAP moves away from it, the Promineo-RA transmits a pre-paging command to the adjacent NAPs to detect the position of the DT. When the DT is disconnected, the Promineo-RA determines an NAP most adjacent to the DT according to the pre-encoded geometric information of the deployed NAPs, and commands the NAP to connect the DT.

The Promineo-DT uses a PPP associated RFCOMM (serial cable emulation protocol) model defined in the Bluetooth LAN access profile (LAP).

Moreover, the DT has a few additional functions for supporting the handover mechanism. That is, when the DT is disconnected during the handover mechanism, it should maintain the PPP session until the handover mechanism is completed. In order to receive a connection request from a new AP, the DT has a function of entering into a continuous page scan mode. The DT satisfying the aforementioned conditions can be the Promineo-DT.

The LAP which is a network connection standard of the Bluetooth Spec. 1.1 executes network connection through the PPP on the RFCOMM which is a serial communication emulation layer. Whenever the user apparatus changes connection from one NAP to another NAP due to movement, inquiries/connections must be performed as well as the PPP connection must be newly attempted. Accordingly, time consumption is increased due to inquiries/connections and information on the previous connection is lost due to the new PPP connection. That is, it generates time delay due to the handover mechanism and packet loss due to disconnection of the PPP.

Therefore, the existing PPP connection state must be maintained during the handover/roaming mechanism, regardless of disconnection of the Bluetooth link. For this, the Promineo-AP of the invention is designed

to be operated in a dual mode, for individually supporting the generalized LAP and the handover/roaming mechanism. That is, when the RA is not used, the Promineo-AP is operated as the generalized NAP including a PPP server and network address translation (NAT). In addition, in order to support the handover/roaming mechanism, the PPP server is positioned not on the NAP but on the RA, and the NAP managed by the RA performs a proxy operation for relaying a PPP diagram through tunneling as shown in Fig. 2. Therefore, the PPP connection on the RA is valid during the NAP to NAP handover mechanism of the user apparatus. When the handover mechanism is completed, the RA recovers the PPP connection through tunnel end point redirection.

In addition, in order to reduce the packet loss and improve packet transmission, the RA performs packet buffering in consideration of the time delay generated due to the handover mechanism and a data transfer rate. Since the user apparatus does not sense that the PPP service is executed not in the NAP which is the connection object but in the RA, it cannot distinguish this connection from the general network connection using the LAP.

Fig. 3 shows an initial connection setup in accordance with the preferred embodiment of the present invention.

The DT is initially connected to the network according to the LAP. That is, the DT performs inquiries and paging to the network, and enters the Piconet called as the Bluetooth network composed of a master and corresponding slaves through a master/slave switch. Here, the AP is the master and the DT is the slave.

When connection is finished, the AP confirms whether the DT is the Promineo-DT or general DT (by using a name request or SDP).

Fig. 4 shows measurement of the clock offset in accordance with the preferred embodiment of the present invention.

When the DT connected to one AP (AP_1) is disconnected from the AP and connected to another AP (AP_2), the AP_2 needs clock_offset information between the DT and AP_2 for faster paging.

For this, the Bluetooth modules of the APs can calculate a relative clock offset between the DT and the AP_2 by using the clock offset between the DT and the previously-connected AP_1 and the offset between the AP_1 and the AP_2 stored in the RA through the inquiry to the APs.

The clock offset is calculated between the two Bluetooth modules existing in one AP through the inquiry. Since the data communication is disabled during the inquiry, it is executed by using the secondary Bluetooth module. Actually, only 5 upper bits (1.28sec resolution) of the clock offset

value 15bits are used for paging. The calculated clock offset value needs not to be updated for an extended period of time even in consideration of a clock drift.

Fig. 5 shows link loss detection and handover mechanism based on a radio signal strength indicator (RSSI).

When a radio signal strength measurement value read from the AP (AP1) connected to the DT is lower than a predetermined value Link_lost_th, the AP forcibly disconnects itself from the DT by using HCI_disconnect_command. Here, the reason code of 0xFF is used as reason code which is one of the elements of the HCI_disconnect_command, so that this disconnection can be distinguished from disconnections due to authentication failure or the like (For User Ended Connection, 0x13 is used). The disconnected DT enters into the R0 page scan mode and performs continuous page scan. The RA transmits handover initiation command to one (AP_2) of the adjacent APs for connection according to predetermined position information (explained below). While the DT is being connected, the AP_1 cannot communicate with the previously-connected DTs. When the DT maintains the R0 page scan mode, it can respond within a first page train (10ms), which is very short.

Fig. 6 shows link loss detection and handover mechanism based on a

link supervision timer.

When it is difficult to use the RSSI, link loss must be detected by using the link supervision timer. A basic value of a link supervision timeout is 20 seconds. However, the basic value must be reduced (to about 1 second) by using HCI_write_link_supervision_timeout command to decrease a delay time due to the handover mechanism, after the DT is connected to the AP_1. When the link supervision timer is used, if the timer expires, the DT and the AP_1 receive HCI_disconnect_complete event (reason code: connection timeout 0x08). Thereafter, the DT enters into the R0 page scan mode, and the AP_1 informs the RA of disconnection. The RA transmits a command to the APs adjacent to the AP_1 to sequentially attempt connection to the DT.

In this case, the link supervision timeout must be reduced, which may seriously restrict a number of the slaves entering into a park mode.

The two methods presume that the DT is operated in the R0 page scan mode after disconnection. The Promineo-DT performs the continuous page scan for a predetermined time (bw_page_scan_timeout: basic value 2.56 seconds) after disconnection.

On the other hand, when the DT is not the Promineo-DT and thus not operated as described above (AP confirms it after initial connection

setup), paging for new connection may take a long time. When the DT is disconnected from an AP and the handover mechanism starts, the PPP session must be maintained. After the DT is connected to a new AP, connection of the RFCOMM is simply performed. For this, Promineo-DT software exists between the RFCOMM and the PPP of the DT to maintain the PPP session.

Since the packet loss by the handover mechanism may seriously increase delay, the RA has packet buffers in each session, stores packets during the disconnection period and transmits them right after the handover mechanism, thereby minimizing the total handover delay. Here, a size of the packet buffer is dependent upon the handover delay and the packet transfer rate.

The above-explained process of the handover mechanism will now be summarized.

When the Promineo-DT enters the service area of the Bluetooth network system and intends to be connected to the network, it is connected to the adjacent Promineo-AP using LAN access profile. When the Promineo-DT is disconnected from the Promineo-AP_0, it needs to be connected to another AP. The APs adjacent to the AP_0 form a candidate group which the Promineo-DT can be connected to after the handover

mechanism. The candidate APs are indicated by AP_1, AP_2,⋯, AP_n.

When the handover measurement value (for example, RSSI) is lower than a predetermined critical value, the AP_0 initiates the handover mechanism as follows:

1. The AP_0 informs the Promineo-RA of initiation of the handover mechanism. The Promineo-RA stores packets toward the Promineo-DT.

2. The AP_0 ends connection to the Promineo-DT. Here, 1 byte of the reason command parameter showing the reason for connection termination must be set up in the HCI-DISCONNECT command. In order to distinguish the disconnection from disconnections due to other reasons such as deficiency of the AP resources or power failure, the reason parameter is set up as OxFF, namely one of the values reserved for future use in the current version of the Bluetooth specifications.

3. The DT enters into the continuous page scan mode for $T_{handover\_timeout}$ seconds. $T_{handover\_timeout}$ seconds should be long enough to allow all the APs of the candidate group to page the DT.

4. The AP_0 selects the APs from the candidate group so that the distance among the APs can be long enough to prevent interferences during the paging process. The AP_0 transmits handover command messages including the Promineo-DT information to the selected APs.

5. The selected APs intend to page the Promineo-DT by using BD_ADDR of the Promineo-DT. The selected APs transmit paging messages for $T_{page\_timeout}$ sufficiently long to compensate for possible wireless channel errors.

6-1. When all the selected APs fail to be connected to the Promineo-DT, the AP_0 selects another APs from the candidate group and repeats steps 4 and 5.

6-2. When the AP succeeds in connection setup to the Promineo-DT, the AP transmits a handover success message to the AP_0. The master/slave switching does not occur during the handover mechanism, since the access point initiates the connection establishment. When receiving the message, the AP_0 directly informs the Promineo-RA of completion of the handover mechanism. The Promineo-RA re-transmits the packets to the Promineo-DT by generating a new PPP channel or renewing a routing table.

7. When all the APs of the candidate group AP_1, AP_2,…, AP_n fail to connect to the Promineo-DT, if the Promineo-DT re-enters the allowable range of the AP_0, the AP_0 intends to finally page the Promineo-DT.

8. In the case that any of the APs cannot be connected to the Promineo-DT, the handover mechanism fails and the resources allocated

to the Promineo-DT are released.

The main object of the handover mechanism is that the APs alternately perform paging when the Promineo-DT maintains the continuous page scan mode. In order to guarantee successful handover mechanism, the candidate group must be selected to cover the whole areas which the user moves during the handover mechanism.

In addition, the Promineo-AP can include a plurality of Bluetooth modules, and thus can be connected to a module different from the previously-connected module in the same AP.

A Promineo protocol is defined between the AP and the RA for the handover mechanism. The Promineo protocol is divided into a Promineo command from the RA to the AP and a Promineo event from the AP to the RA, and transmitted in XML data form for extensibility.

The Promineo protocol for the handover/roaming mechanism will now be described.

1. LAP<->LAP protocol

The LAPs communicate with each other by using an UDP channel. Each LAP generates UDP sockets having a standardized port number and transmits messages through the UDP sockets. The LAP receiving the message guarantees reliability of the channel by transmitting ACK.

When the sender does not receive the ACK for a predetermined time after transmitting the message, the sender judges that packet loss has been generated and re-transmits the message. When the message is normally transmitted but the ACK is lost, the LAP may receive a redundant message. In order to ignore the redundant message, a sequence number is added to the message. When the sequence number of the received message is identical to that of the previously-received message, the LAP ignores the received message.

1 byte (0~255) is used to display the sequence number. The sender and the receiver record and use finally-transmitted and received numbers. For example, when LAP1 transmits/receives messages to/from LAP2 and LAP3, the LAP1 should memorize the sequence numbers of the messages respectively transmitted to the LAP2 and LAP3. In addition, it must record the sequence numbers of the messages from the LAP2 and LAP3.

When the message where a payload length is added to a message header is damaged, the LAP1 requests re-transmission by sending NACK. The whole structure of the message is shown in following Table 1:

<Table 1>

Message

0x00	SEQ. NUM	MSG length	MSG type	Arguments

1byte	1byte	4byte	1byte	n byte

ACK

0x0f	SEQ. NUM
1byte	1byte

NACK

0xff	SEQ. NUM
1byte	1byte

The message is divided into a command type and an event type. The command type message commands the receiver to perform a specific operation, and the event type message notifies a command execution result.

<Table 2>

Command Type

Command	Arguments	Return Event
BW_HANDOVER_COMMAND	bd_addr, module	BW_HANDOVER_SUCCESS_EVENT, BW_HANDOVER_FAIL_EVENT

BW_SEND_BUF_DATA_COMMAND	bd_addr, buf_data	

Event Type

EVENT	Arguments	Return Event
BW_HANDOVER_SUCCESS_EVENT	bd_addr, module, line	
BW_HANDOVER_FAIL_EVENT	bd_addr	

2. Communication between LAP<->RA

The LAP and the RA communicate with each other in the same manner as the LAP to LAP communication. The RA generates one UDP socket and communicates with the LAP through the UDP socket. The RA confirms the LAP transmitting the message according to sender sockaddr, and performs a necessary operation (or LAP identifier is added to the message so that the RA can confirm the LAP transmitting the message). Identically to the LAP to LAP communication, reliability of communication is improved by using ACK.

Table 3 shows message types used for the communication.

<Table 3>

MSG Type	Arguments	Direction
BW_LOCATION_INFO_EVENT	4*(module, num, num*(LAP id, module,distance))	Agent→LAP
BW_NEW_DT_EVENT	bd_addr, module, line	LAP→Agent
BW_HANDOVER_START_EVENT	module, line	LAP→Agent
BW_HANDOVER_COMPLETE_EVENT	bd_addr, module, line	LAP→Agent
BW_CLOSE_SESSION_EVENT	module, line	LAP←→Agent

3. Inter-Process Communication

In the LAP, one process is allocated to each DT. The DT process forks processes as many as MAX_DT (a number of modules is 4, and when 7 DTs are connected to each module, a number of processes is 28) in the LAP initialization time point to prevent overload. Accordingly, the main process and MAX_DT DT processes exist in the LAP.

- Main process: LAP to LAP communication, RA communication, BT module control using a stack interface. The main process examines a connection state of the DT by reading RSSI value at a predetermined interval. When the handover mechanism is

necessary, the main process informs the DT process to interrupt data transmission and buffer data.

- DT process: TCP data channel setup for data transmission and reception to/from the RA. When the DT is connected, the DT process opens the BT driver (open ttyBT#) and transmits data between the RA and DT.

The main process and the DT process transmit/receive messages according to pipe and FIFO. Table 4 shows types of the messages between the two processes.

<Table 4>

MSG type	Description	Direction
NEW_DT_EVENT	When the main process of LAP confirms connection from the DT (by using general polling, stack signal transmission or callback function), it informs DT process corresponding to module and line to which the DT is connected of new DT connection.	main → dt process
LINK_LOW_POWER_EVENT	The main process periodically checks RSSI value. When the value is lower than a critical value, the main process informs the RA of roaming initiation not to transmit data, and transmits an event to the DT process to buffer data from the RA through socket. Here, the main process continuously transmits up stream data until receiving DISCONNECT_EVENT.	main → dt process
DISCONNECT_EVENT	The main process is disconnected from the DT by the handover or RA's request, and transmits the event to the DT process. When buffered data exist, the DT process transmits them to the main process, closes ttyBT#, resets all statuses, and waits for NEW_DT_EVENT.	main → dt process

BUFFERED_DATA	Message for transmitting buffered data to the main process after the DT process starts the handover mechanism (receiving LINK_LOW_POWER_EVENT)	dt process → main
WRITE_BUFFERED_DATA	Message for transmitting data by BW_SEND_BUF_DATA_COMMAND to the DT process after connection to new LAP is completed during the handover mechanism	main → dt process
COMPLETE_WRITE_BUF_DATA	Message for confirming that buffered data are all transmitted to the DT. When the main process receives the message, it directly transmits BW_HANDOVER_COMPLETE_EVENT to the agent to set up a transmission path to the DT and starts transmission.	dt process → main

In order to perform the handover/roaming mechanism, geographical positions (position information) of each AP module are stored. The position information can be used to select the candidate group during the handover mechanism. The position information is stored in an adjacent matrix form.

The RA stores the whole position information and the AP stores nodes adjacent its modules. The RA reads the position information of the APs stored in a script form, stores it in its adjacent matrix, and transmits it to each AP. A node of the graph is BT module of the AP and an edge indicates a relative distance. The relative distance is divided into 1) near, 2) overlap (40% overlap) and 3) tangent (tangent areas). In the case of the roaming mechanism due to movement, the module displayed as 'overlap' is set up as the handover destination, and in the case of load balancing for congestion, the handover mechanism is performed on the module displayed as 'near'. The position information is executed when the Promineo-AP is installed, and re-executed when the installation position of the Promineo-AP is changed. The embodiment of the position information will now be explained.

- In the RA,
  - The RA must know topologies of the whole modules existing within the LAN, which modules belong to the same LAP, and adjacent modules of the module if only one module exists.
  - Each LAP has a consecutive number starting from 0.
  - The numbers of the modules are displayed in pairs of LAP number-LAP module number (0~3) (for example, module

2-1: first module from second LAP).

- Adjacent matrix formation

a. declaration : int adj_matrix [module number][module number]

b. index i : LAP number*4+LAP module number

ex) module 2-1 : I = 2*4+1 = 7

d. adj_matrix[i][j] : edge weight between module i and module j, which is the same as adj_matrix[j][i].

c. index j is converted into module number

- LAP number : j%4

- LAP module number : j - j%4 (for example, j = 15 => module 3-3)

d. search for identical module in index j

- distinguish which modules belong to the same LAP by LAP module numbers (for example, switch(LAP module number))

{

case 3 : j-3, j-2, j-1 belong to the same LAP

case 2 : j-2, j-1, j+1 belong to the same LAP

case 1 : j-1, j+1, j+2 belong to the same LAP

case 0 : j+1, j+2, j+3 belong to the same LAP

}

e. Edge size is shown as integers.

– When the integer is over a predetermined value, it is deemed to be a long distance.

■ In the LAP,

- Each LAP must be informed of which topology their Modules compose, whether they are adjacent to modules of another LAP, and numbers of the adjacent modules.

- Adjacent matrix formation

a. declaration : int adj_matrix[4][module number]

b. index i : LAP module number

c. hereinafter, the same as the RA case

Fig. 7 shows one example of network constitution. Following tables 5 to 7 show adjacent matrixes in the network constitution of Fig. 7.

<Table 5>

Adjacent matrix of RA

	0	1	2	3	4	5	6	7
0		3		4				
1	3		4					
2		4		3	6	2	3	

3	4		3		2	5	7	
4			6	2		2	4	
5			2	5	2		1	4
6			3	7	4	1		3
7						4	3	
moduleID	0-0	0-1	0-2	0-3	1-0	1-1	1-2	1-3

<Table 7>

Adjacent matrix of LAP0

	0	1	2	3	4	5	6	7
0		3		4				
1	3		4					
2		4		3	6	2	3	
3	4		3		2	5	7	
4			6	2		2	4	
5			2	5	2		1	4
6			3	7	4	1		3
7						4	3	
moduleID	0-0	0-1	0-2	0-3	1-0	1-1	1-2	1-3

<Table 8>

Adjacent matrix of LAP1

	0	1	2	3	4	5	6	7
0			6	2		2	4	
1			2	5	2		1	4
2			3	7	4	1		3
3						4	3	
moduleID	0-0	0-1	0-2	0-3	1-0	1-1	1-2	1-3

A method for enabling the handover mechanism between a mobile terminal (PAN user : PANU) having the Bluetooth wireless interface and the NAP in a state where the PANU is connected to a network infrastructure through the NAP according to the Bluetooth PAN profile will now be explained.

The NAP includes the Bluetooth wireless interface and the Ethernet interface and exchanges packets between the PANU and the wireless network. As defined in the PAN profile, the NAP is operated in one of Layer 2 bridge and Layer 3 router. Here, it is presumed that the NAP is operated in the bridge which is a basic operation mode of the PAN profile.

The NAP connects Bluetooth Network Encapsulation Protocols (BNEP), regards Ethernet ports as valid bridge ports, and converts and exchanges packets there between (namely, BNEP packet <-> Ethernet packet).

The handover mechanism by the PAN profile will now be explained.

1. Connection to NAP of PANU

The PANU is connected to the NAP according to the PAN profile for generating BNEP connection.

2. Initiation of handover mechanism

The NAP monitors information obtained from the Bluetooth module (link quality, signal strength or distance). When the connection state to the specific PANU (hereinafter, referred to as 'PANU0') is deteriorated or the distance is increased, the handover mechanism is initiated.

3. Order of handover mechanism

(1) The NAP previously connected to the PANU0 (hereinafter, referred to as 'NAP0') is disconnected from the PANU0. In addition, the NAP0 informs the Promineo-RA of initiation of the handover mechanism on the PANU0.

(2) The PANU0 recognizes disconnection for the handover mechanism by confirming a reason code parameter of the disconnection command, and enters into the continuous page scan mode.

(3) While the handover mechanism is being performed, the NAP0 buffers data transmitted to the PANU0 in the memory in the Ethernet packet form.

(4) The NAP0 transmits the handover command message including PANU0 information sequentially to the adjacent NAPs (similar to the above-described candidate group of the handover mechanism according to the position information order). The NAPs receiving the handover command message perform paging for $T_{page\_timeout}$ to attempt connection to the PANU0.

(5) The NAP succeeding in paging the PANU0 (hereinafter, referred to as 'NAP1') generates BNEP connection to the PANU0, and transmits the handover success message to the NAP0 and the Promineo-RA to notify it.

(6) The NAP0 interrupts buffering of the packets transmitted to the PANU0 by removing MAC address (BD_ADDR) of PANU0 in the entry of its packet filtering database, and transmits the handover success acknowledge message to the NAP1. In addition, the NAP0 transmits the buffered Ethernet packets to the NAP1.

(7) The NAP1 receiving the handover success acknowledge message adds MAC address (BD_ADDR) of the PANU0 to the entry of its packet filtering database, receives the packets transmitted to the PANU0

and buffers them in its memory. The NAP1 transmits the whole Ethernet packets stored in the NAP0 to the PANU0, and transmits its received packets to the PANU0.

In addition, the NAP can include a plurality of Bluetooth modules. Accordingly, the NAP can be connected from a module different from the previously-connected module in the same NAP.

INDUSTRIAL APPLICABILITY

As described above, the present inventions allow the Bluetooth to solve problems due to frequent inquiries/connections during the movement of the generalized Bluetooth user apparatus, and overcomes distance limit which is the one of disadvantages of the Bluetooth by extending the service area through the handover/roaming mechanism supporting system.

WHAT IS CLAIMED IS:

1. A handover/roaming mechanism supporting system in a short-range wireless network based on the Bluetooth, comprising:

at least one Promineo-access point (Promineo-AP) which is a network access point (NAP) for connecting a Bluetooth user apparatus through the LAN;

at least one Promineo-data terminal (Promineo-DT) loaded with Bluetooth client application software for supporting handover/roaming mechanism; and

a Promineo-roaming agent (Promineo-RA) for supporting the handover/roaming mechanism on a wired backbone and managing all the Bluetooth apparatuses within the service area, wherein the Promineo-AP connects the Promineo-DT through the LAN, informs the RA of BD_ADDR and clock_offset information of the DT, sets up connection according to a command from the RA and performs a proxy operation for relaying a PPP diagram, and the Promineo-RA serves as a PPP server for processing PPP connection to the DT in a sub-network including the NAPs, recovers the PPP connection through tunnel end point redirection after the handover mechanism is completed, and thus maintains the previous PPP connection

state during the handover/roaming mechanism regardless of disconnection of the Bluetooth link.

2. The system of claim 1, wherein the Promineo-RA buffers packets by PPP sessions in consideration of time delay generated due to the handover mechanism and a data transfer rate in order to remove packet loss and improve packet transmission.

3. The system of either claim 1 or 2, which processes commands and events between the Promineo-AP and the RA by using a predetermined Promineo protocol.

4. The system of either claim 1 or 2, wherein clock offset information between the DT for determining a paging/connection time between the DT and the Promineo-AP and the newly-connected AP (AP2) is calculated as a relative clock offset between the DT and the AP2 by using the clock offset between the DT and the previously-connected AP (AP1) and the clock offset between the AP1 and the AP2 stored in the RA through the inquiry to the APs.

5. The system of claim 1, which is operated according to LAN access profile and/or PAN profile.

6. The system of claim 1, wherein the Promineo-AP performs a main process for executing communication between the plurality of Promineo-APs and communication to the Promineo-RA, controlling BT module by using a stack interface, and examining a connection state of the Promineo-DT by reading a radio signal strength indicator (RSSI) value at a predetermined interval; and performs a DT process for setting up TCP data channel for data transmission and reception to/from the Promineo-RA, and opening a BT driver when the Promineo-DT is connected, and transmitting data between the Promineo-RA and the Promineo-DT, wherein, when the handover mechanism is necessary, the main process interrupts connection to the Promineo-DT and the DT process receives and buffers data transmitted to the DT.

7. The system of claim 6, wherein the DT disconnected from the Promineo-AP enters into a continuous page scan mode (R0 page scan mode) to reduce the delay of the whole handover mechanism.

8. The system of claim 1, wherein, when the Promineo-AP is installed, the Promineo-RA generates and stores position information comprised of adjacent matrixes showing relative distances to the Promineo-APs, and when the handover mechanism is necessary, the Promineo-RA determines the Promineo-AP to be connected according to the position information.

9. The system of either claim 1 or 8, wherein, each of the Promineo-APs comprises a plurality of Bluetooth modules, and when the multiple Bluetooth modules are installed, the Promineo-AP generates and stores position information comprised of adjacent matrixes showing relative distances between the modules of the Promineo-AP and relative distances to modules of another Promineo-AP, and when the handover mechanism is necessary, the Promineo-AP determines the module to be connected according to the position information.

1/6

FIG. 1

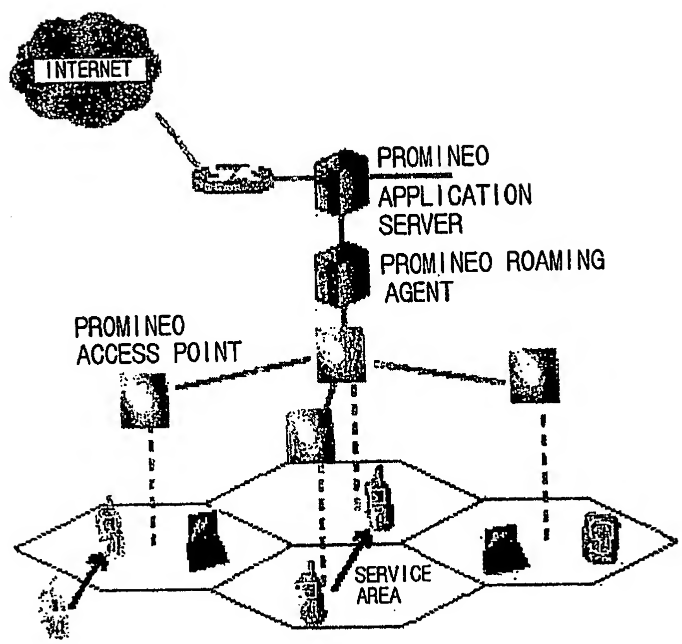

INTERNET
PROMINEO
APPLICATION
SERVER
PROMINEO ROAMING
AGENT
PROMINEO
ACCESS POINT
SERVICE
AREA

FIG. 2

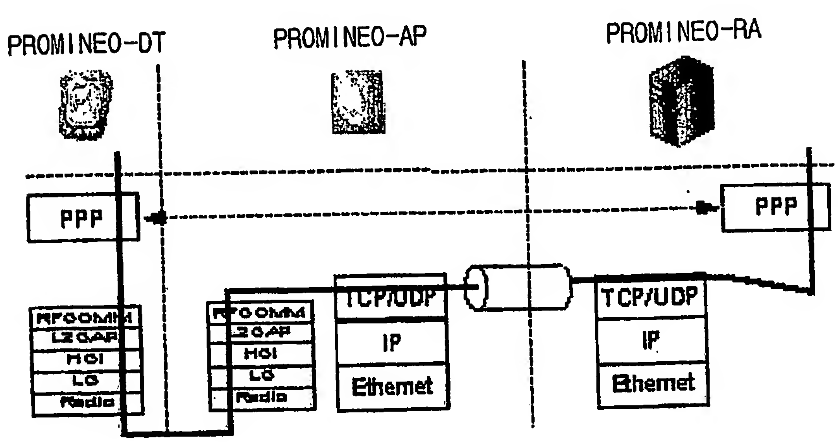

PROMINEO-DT
PROMINEO-AP
PROMINEO-RA
PPP
PPP
TCP/UDP
IP
Ethernet
TCP/UDP
IP
Ethernet
RFCOMM
L2CAP
HCI
LC
Radio
RFCOMM
L2CAP
HCI
LC
Radio

FIG. 3

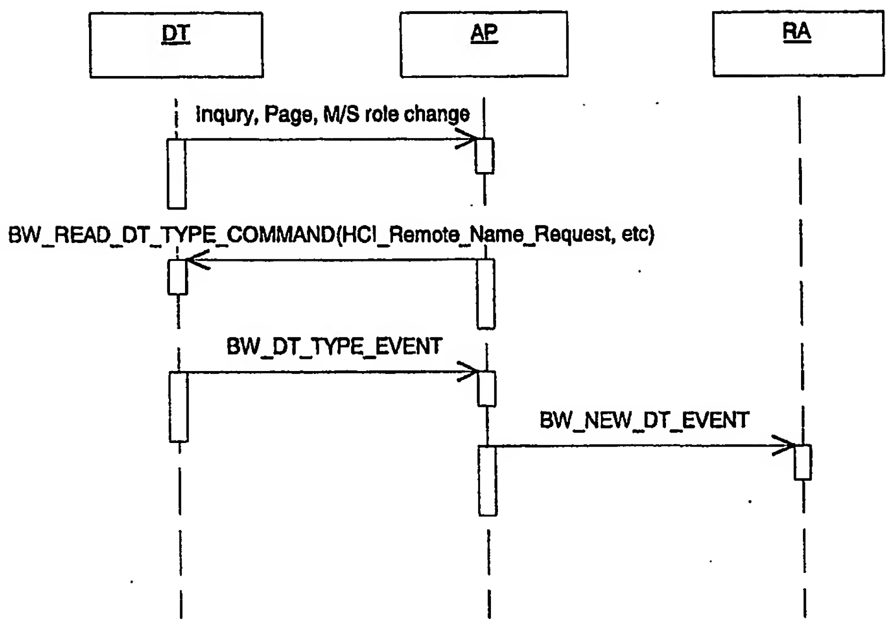

DT
AP
RA
Inqury, Page, M/S role change
BW_READ_DT_TYPE_COMMAND(HCI_Remote_Name_Request, etc)
BW_DT_TYPE_EVENT
BW_NEW_DT_EVENT

FIG. 4

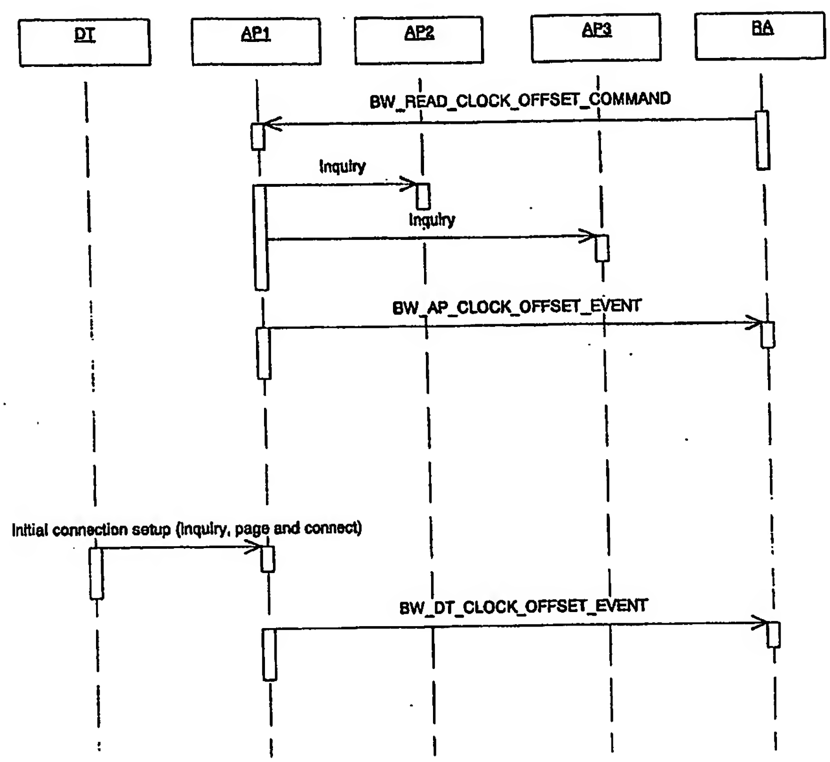

DT
AP1
AP2
AP3
BA
BW_READ_CLOCK_OFFSET_COMMAND
Inquiry
Inquiry
BW_AP_CLOCK_OFFSET_EVENT
Initial connection setup (inquiry, page and connect)
BW_DT_CLOCK_OFFSET_EVENT

FIG. 5

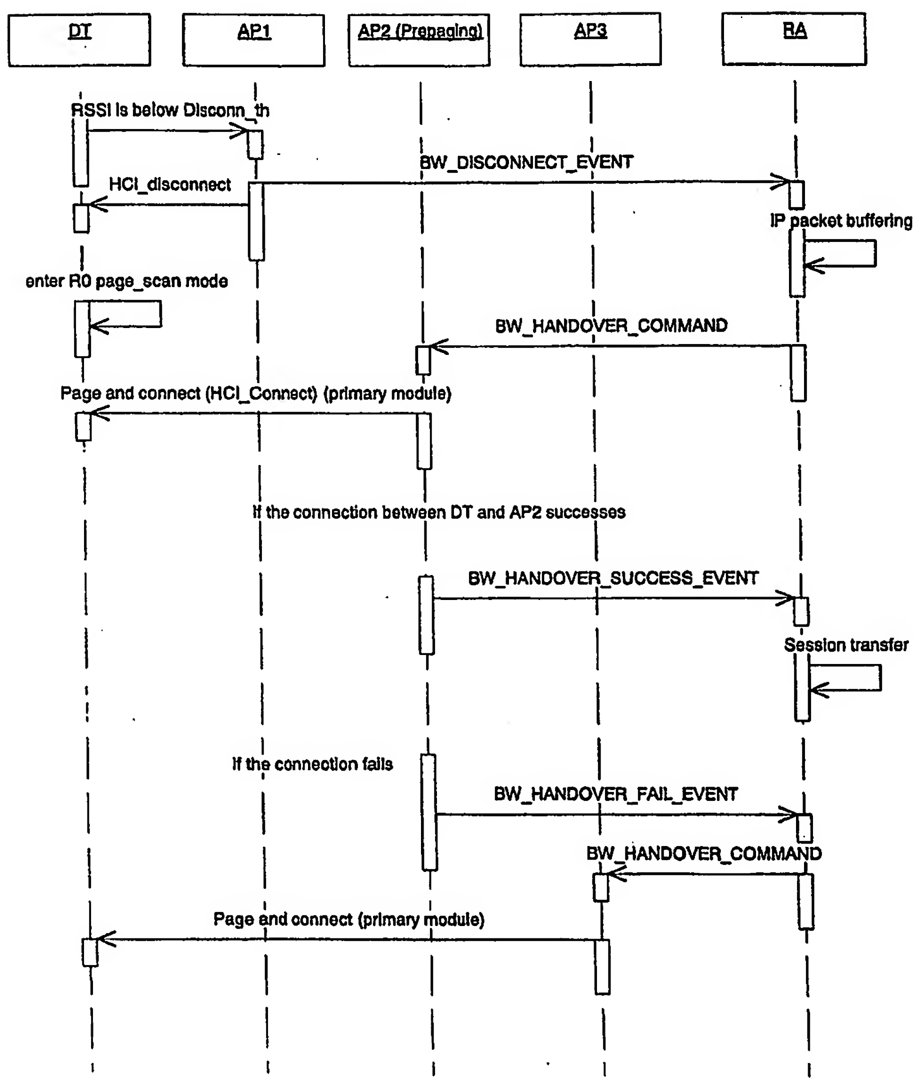

DT
AP1
AP2 (Prepaging)
AP3
RA
RSSI is below Disconn_th
BW_DISCONNECT_EVENT
HCI_disconnect
IP packet buffering
enter R0 page_scan mode
BW_HANDOVER_COMMAND
Page and connect (HCI_Connect) (primary module)
If the connection between DT and AP2 successes
BW_HANDOVER_SUCCESS_EVENT
Session transfer
If the connection fails
BW_HANDOVER_FAIL_EVENT
BW_HANDOVER_COMMAND
Page and connect (primary module)

FIG. 6

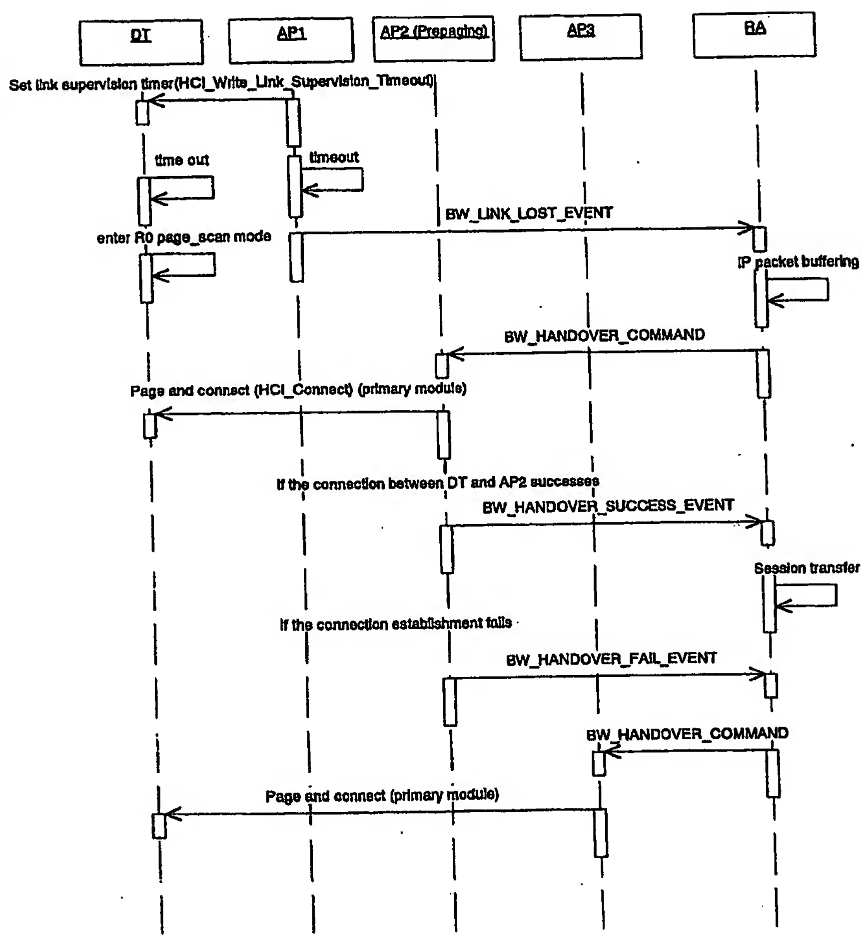
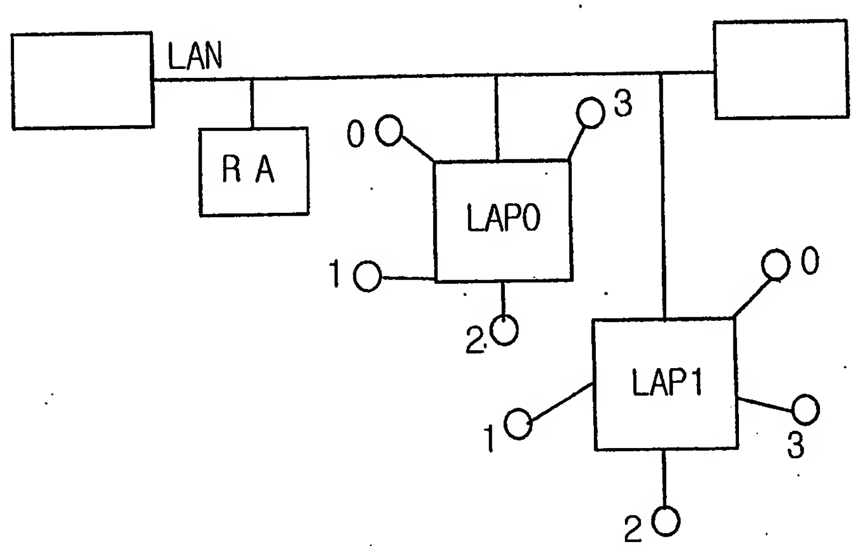

DT
AP1
AP2 (Prepaging)
AP3
BA
Set link supervision timer(HCI_Write_Link_Supervision_Timeout)
time out
timeout
BW_LINK_LOST_EVENT
enter R0 page_scan mode
IP packet buffering
BW_HANDOVER_COMMAND
Page and connect (HCI_Connect) (primary module)
If the connection between DT and AP2 successes
BW_HANDOVER_SUCCESS_EVENT
Session transfer
If the connection establishment fails
BW_HANDOVER_FAIL_EVENT
BW_HANDOVER_COMMAND
Page and connect (primary module)

FIG. 7



INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR02/01533

A. CLASSIFICATION OF SUBJECT MATTER

IPC7 H04B 7/26

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 G06F, H04B, H04L, H04M, H04Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Korean Patents and applications for inventions since 1975, Korean Utility models and applications for Utility models since 1975, IEEE technical document since 1980

Electronic data base consulted during the intertnational search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0851633 A2 (Lucent Technologies Inc.) 1 Jul, 1998 See the whole document	1,2,3,5
A, P	KR 2002-23917 A (iMnetpia) 29 Mar. 2002 See the whole document	1,3,5
A	EP 0605957 A1 (NCR INT INC) 13. Jul. 1994 See the whole document	1
A, P	KR 2002-30504 A (LG Electronics) 25 Apr. 2002 See the whole document	1,3,5

☐ Further documents are listed in the continuation of Box C.   ☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevence
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevence; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevence; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents,such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
25 NOVEMBER 2002 (25.11.2002)	26 NOVEMBER 2002 (26.11.2002)

Name and mailing address of the ISA/KR
Korean Intellectual Property Office
920 Dunsan-dong, Seo-gu, Daejeon 302-701,
Republic of Korea
Facsimile No. 82-42-472-7140

Authorized officer
KIM, Yong Jae
Telephone No. 82-42-481-5716

INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR02/01533

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0851633 A2	1 Jul, 1998	CA 2221948 A1 JP 10210533 A	30. 06. 1998 07. 08. 1998
KR 2002-23917 A	29 Mar. 2002	None	
EP 0605957 A1	13. Jul. 1994	DE 69325438 D1 JP 6237251 A US 5371738 A	29. 07. 1999 23. 08. 1994 06. 12. 1994
KR 2002-30504 A	25 Apr. 2002	None	